PROPERTIES OF A TIRE WITH SENSOR SIGNALS OF SPEED OF DEFORMATION

DESCRIPTION

The present invention, in its most general aspect,
relates to a method for measuring characteristic
properties of a pneumatic tyre for vehicle wheels. More
specifically, the invention relates to a method for
detecting the size of the footprint area of a pneumatic
tyre for vehicle wheels in high-speed motion conditions,
and the distribution of pressure on such a footprint
area.

Throughout the present description and the subsequent
claims, the term: characteristic properties of a
pneumatic tyre, is used to indicate, for example, the
dimensions and/or the shape of the footprint area of the
tyre, the distribution of pressure (or vertical forces)
acting locally on the footprint area of the tyre, the
tyre inflation pressure, the distribution of longitudinal
and/or lateral forces acting on the tyre and the rolling
resistance.

The term: footprint area, is used to indicate that zone
of the tyre wherein the exchange of forces between the
tyre and the road surface (or between the tyre and a
device simulating the road surface, such as a rolling
runway of a drum simulating the road surface) takes
place, i.e. that zone of the tyre which is in contact
with the road surface (or with the device simulating the
road surface).

The term: high-speed, is used to indicate a speed greater
than 30 km/h, preferably greater than 100 km/h, even more
preferably greater than 200 km/h.

As known, a considerable part of the research in the
field of tyres for vehicle wheels has as a primary object
that of optimising the design parameters of the tyre to

ensure adequate behaviour thereof in the foreseen operating conditions. For such a purpose, tyres are inspected and tested to detect some properties representing the behaviour of the tyre in operation.

5   For example, it is used to measure the size and/or the shape of the footprint area of a tyre and to detect the variation of such a size and/or shape as the rolling speed of the tyre varies. Indeed, it is known that a properly designed tyre has a wide, rectangular or square 10   footprint area which substantially does not change as the rolling speed of the tyre changes.

Also, it is used to measure the distribution of pressure on the footprint area of the tyre and, even in this case, to detect the variation of such a distribution of 15   pressure as the rolling speed of the tyre varies. Indeed, it is known that a properly designed tyre has a substantially uniform distribution of pressure between the shoulders and the center of the tyre, such a distribution being also substantially invariable as the 20   rolling speed of the tyre varies.

Thus, for example, US 5,749,984 discloses a method for monitoring a tyre wherein a measurement of the size of the footprint area of the tyre is carried out by a sensor suitably housed inside the tyre. In the preferred 25   embodiment thereof, the sensor is a piezoelectric element which deforms when the tyre comes into contact with the ground thus generating an electrical signal proportional to the speed of deformation thereof. The position of the sensor inside the tyre is described as being particularly 30   critical for generating a suitable electrical signal.

The Applicant has observed that this system is an invasive detection system (i.e. the sensor is provided inside the tyre) and thus it involves complication in the production process of the tyre, as well as it requires 35   the production of tyres ad hoc. The Applicant has also

verified that a system as the one described in the patent
identified above does not allow the actual duration of
contact between tyre and road, and therefore the length
of the footprint area of the tyre, to be determined with
5   precision. Indeed, the signal generated by the sensor is
influenced by phenomena which take place before or after
the tyre contacts the road. The Applicant has also
observed that such a patent does not provide any
indication of the shape of the tyre footprint, nor of the
10   distribution of pressure on the footprint area.

A non-invasive system for detecting the distribution of
pressure on the footprint area of a tyre under almost
static conditions is disclosed in patent application EP 0
656 269. Such a system provides for the use of a
15   plurality of arrays of load sensors directly applied on
the road surface. Such sensors directly measure the
vertical forces acting upon the footprint area of the
tyre and generate an electrical signal proportional to
such forces. The Applicant observes that, in line with
20   the disclosure of the aforementioned document, such a
system is capable of detecting the distribution of
pressure for static conditions or for rolling speeds of
the tyre lower than 5-6 Km/h, greater speeds being ruled
out due to the limited and/or insufficient frequency
25   response of the load sensors.

The Applicant has faced the problem of detecting one or
more characteristic properties of a pneumatic tyre (such
as the size and/or shape of the footprint area and the
distribution of pressure on the footprint area) in high-
30   speed motion conditions (such as 100 km/h) by a non-
invasive system and in generic operating conditions of
the tyre and has perceived and verified that such a
problem is solved by measuring the speed of deformation
of at least one array of deformable sensors (i.e. the
35   speed of the impact between tyre and sensors and
therefore the variation of pressure on the sensors) and

subsequently deriving from such a measurement, through simple calculation operations and/or simple detections or analyses of the measurement signal, the desired characteristic properties of the tyre (such as the length of the footprint area or the distribution of pressure on the footprint area).

Therefore, the present invention, in a general aspect thereof, relates to a method for measuring characteristic properties of a pneumatic tyre for vehicle wheels, comprising the steps of:

- arranging at least one array of deformable sensors along a direction y transversal to a motion direction x of a pneumatic tyre for vehicle wheels, said at least one array of sensors extending for a length at least equal to the dimension of said pneumatic tyre along said direction y;

- making said pneumatic tyre pass at speed over said at least one array of sensors along said motion direction x;

- generating, for each sensor of said at least one array of sensors, an electrical signal proportional to a speed of deformation of said sensors when they contact said pneumatic tyre;

- detecting said electrical signal generated by each sensor of said at least one array of sensors;

- determining, starting from each detected electrical signal, at least one characteristic property of said pneumatic tyre.

Throughout the present description and the subsequent claims, the term: motion of a pneumatic tyre, is used to indicate any condition of movement of the pneumatic tyre with respect to the road surface or to any device simulating the road surface, such as the rolling runway of a drum simulating the road surface. Therefore, either motion by rolling and slipping or sliding of the tyre are considered. For the sake of simplicity, however, explicit reference will be made to a motion by rolling of the

tyre.

Moreover, throughout the present description and the
subsequent claims, the term: direction transversal to the
motion direction of the pneumatic tyre, is used to
5   indicate any direction tilted by an angle other than zero
with respect to the motion direction of the tyre, and
therefore not necessarily a direction perpendicular to
the motion direction of the tyre, thus making it possible
to analyse the behaviour of the tyre even in slipping or
10   camber conditions. For the sake of simplicity, however,
explicit reference will be often made to a direction
perpendicular to the motion direction of the tyre.

Again, throughout the present description and the
subsequent claims, the term: characteristic properties of
15   a pneumatic tyre, is used to indicate any quantity or
parameter indicating a specific operating condition of
the tyre, such as, for example, the size and/or shape of
the footprint area of the tyre, the distribution of
pressure on the footprint area, the inflation pressure of
20   the tyre, the distribution of longitudinal and/or lateral
forces acting upon the tyre, the rolling resistance. For
the sake of simplicity, however, explicit reference will
be often made to the size and/or shape of the footprint
area of the tyre and/or to the distribution of pressure
25   (vertical forces) on such a footprint area. Any person
skilled in the art will, however, understand that the
method of the present invention can also be carried out
for measuring the other quantities listed above.

Advantageously, therefore, the method of the present
30   invention allows the behaviour of a tyre to be observed
even in high-speed motion conditions and in generic
operating conditions (for example in rolling, sliding,
slipping and camber conditions of the tyre) by a non-
invasive detection system, i.e. by sensors provided
35   outside of the tyre. Preferably, the motion speed of the
tyre is equal to or greater than 30 km/h, more preferably

equal to or greater than 100 km/h, even more preferably
equal to or greater than 200 km/h.

In accordance with the present invention, rather than
directly detecting the forces acting on load sensors, as
5   suggested in document EP 0 656 269, it is particularly
advantageous to detect the speed of deformation of
suitable deformable sensors which, unlike load sensors,
have high frequency response, thus allowing the behaviour
of the tyre at high speeds to be detected. Also, the fact
10   that such sensors are provided outside of the tyre makes
the method of the present invention suitable for
operating irrespective of the type and model of the tyre,
without requiring the production of tyres ad hoc, nor
complicating the production process thereof.

15   In accordance with the present invention, it is
advantageously possible, for example, to determine the
length of the footprint area of a tyre, in high-speed
motion conditions, for the entire width of the tyre, and
to outline the shape of such a footprint area, by simply
20   arranging an array of deformable sensors along a
direction transversal to the motion of the tyre and
making the tyre pass over such sensors. Upon contacting
the tyre, each sensor generates an electrical signal
proportional to the speed of deformation of the sensor
25   itself. By analysing such an electrical signal it is
possible to determine the length of the footprint area
measured at the position in which the sensor is located.
The overall shape and size of the footprint area are
obtained by combining the analogue information obtained
30   from the other sensors of the array of sensors.

By proceeding then with a simple integration in time of
the electrical signals detected by the individual
deformable sensors it is advantageously possible to
determine also the distribution of pressure acting upon
35   the footprint area of the tyre. The detection system of
the present invention thus differs from the currently

known non-invasive detection systems, as the one described in the aforementioned patent application EP 0 656 269, in that a direct measurement of the vertical forces acting upon the footprint area through load

5   sensors is not carried out, but such forces are obtained through a simple calculation operation starting from a measurement of the speed of deformation of deformable sensors.

In accordance with a first way of implementation thereof,

10 the method of the present invention is carried out to determine just the size and/or shape of a footprint area of a pneumatic tyre in high-speed movement.

In accordance with a second way of implementation thereof, the method of the present invention is carried

15 out to determine just the distribution of the pressure acting upon the footprint area of a pneumatic tyre in high-speed movement.

In accordance with a preferred way of implementation thereof, the method of the present invention is carried

20 out to determine either the size and/or shape of the footprint area of a pneumatic tyre in high-speed movement, and the distribution of pressure acting on such a footprint area. Through such a method the evolution of the size and/or shape of the footprint area and the

25 distribution of pressure as the speed varies is also determined in conditions of rolling, slipping or sliding of the tyre.

In further ways of implementation thereof, the method of the present invention can also be carried out to

30 determine other characteristic properties of a pneumatic tyre, as for example the inflation pressure thereof, the distribution of longitudinal and/or lateral forces and the rolling resistance.

In the preferred way of implementation of the method of

the present invention, a plurality of arrays of sensors
are arranged all substantially parallel and transversal
to the motion direction x of the pneumatic tyre, so as to
obtain a greater resolution in the determination of the
5   size and/or shape of the footprint area of the tyre
and/or in the distribution of pressure on such a
footprint area. Preferably, the various arrays of sensors
are ordered according to a staggered arrangement so as to
obtain the desired resolution by providing a greater
10 number of sensors in a predetermined detection area.

Preferably, the deformation sensors used in the method of
the present invention comprise piezoelectric elements,
such as pieces of piezoelectric cable, or piezoelectric
film, or else quartz, in general being suitable for the
15 purposes of the present invention all those materials
which, when deformed, produce a concentration of
electrical charge and thus an electrical signal (for
example, an electrical current or voltage).
Advantageously, the piezoelectric elements or the quartz
20 do not require an electrical supply, thus simplifying the
detection system of the present invention.

Even more preferably, the deformation sensors comprise
piezoelectric cables which can be directly pressed by the
tyre or, alternatively, by a plunger upon which the tyre
25 impacts. Such sensors can be directly housed in a
suitable seat provided on the road surface (in case of
outdoor measurements) or on a rolling runway of a drum
simulating the road surface (in case of indoor
measurements). Preferably, the sensors are previously
30 associated with a support plate which is then adapted to
be housed on the road surface or on the drum simulating
the road surface. This simplifies and accelerates the
assembly, disassembly and adjustment operations of the
individual sensors.

35 Further characteristics and advantages of the present
invention shall become clearer from the following

detailed description of some embodiments or way of implementation thereof, made with reference to the attached drawings. In such drawings:

- figure 1 shows a schematic view of a first embodiment
5 of a system for measuring characteristic properties of a tyre which actuates the method of the present invention;

- figure 2 shows a schematic view of a second embodiment of a system for measuring characteristic properties of a tyre which actuates the method of the
10 present invention;

- figure 3 shows a schematic view of a support plate for the sensors used in the method of the present invention;

- figures 4(a) and 4(b) respectively show a schematic
15 section view and a schematic perspective view of a sensor of the support plate of figure 3;

- figure 5 schematically shows the sensor of figures 4(a) and 4(b) in an exploded condition;

- figure 6 shows the trend of the electrical signal
20 generated by the sensor of figures 4(a) and 4(b) as a function of time;

- figure 7 shows the trend of the electrical signal of figure 6 as a function of the number of sampling points for six linearly increasing vertical loads;

25 - figure 8 shows the signals of figure 6 numerically integrated based upon the vector n° of points (Volts per unit);

- figure 9 shows the length of the footprint of the tyre at a sensor for six linearly increasing vertical
30 loads;

- figure 10 shows the map of a footprint area of a tyre in high-speed motion conditions, obtained using seven sensors for eight linearly increasing vertical loads;

- figure 11 shows the map of figure 10 compared with
35 the one obtained in static conditions;

- figure 12 shows a three-dimensional map of the distribution of pressure on the footprint area;

- figure 13a shows the evolution of the size of the

footprint area for a right slip test;

- figure 13b shows the evolution of the size of the footprint area for a left slip test;

- figure 14a shows the map of distribution of pressure on the footprint area for a right slip test;

- figure 14b shows the map of distribution of pressure on the footprint area for a left slip test;

- figures 15a, 15b, 15c show the maps of distribution of pressure on the footprint area for three increasing levels of inflation pressure and figure 15d shows the relative shapes of the footprint area;

- figures 16a, 16b, 16c show the maps of distribution of pressure on the footprint area for three increasing levels of vertical load and figure 16d shows the relative shapes of the footprint area;

- figures 17a, 17b, 17c show the maps of distribution of pressure on the footprint area for three increasing levels of motion speed of the tyre and figure 17d shows the relative shapes of the footprint area.

In figures 1 and 2, a system for measuring characteristic properties of a tyre 2 for vehicle wheel in high-speed movement, in accordance with the method of the present invention, is indicated with 1. Preferably, the tyre 2 moves at a speed greater than 30 km/h, more preferably equal to or greater than 100 km/h and even more preferably equal to or greater than 200 km/h.

In particular, the system 1 allows one or more characteristic properties of the tyre 2 to be detected in order to evaluate the behaviour of the tyre in generic operating conditions. Such properties are, for example, the size and/or shape of the footprint area of the tyre, the distribution of pressure on the footprint area, the inflation pressure of the tyre, the distribution of longitudinal and/or lateral forces acting upon the tyre, the rolling resistance. For the sake of simplicity, in the following of the present description we shall

consider just the size and/or shape of the footprint area
of the tyre and the distribution of pressure (of the
vertical forces) on such a footprint area.

As illustrated in figures 1 and 2 and as better described
5   in the following of the present description, the system 1
which actuates the method of the present invention allows
to carry out either outdoor measurements (figure 1) and
indoor measurements (figure 2).

Irrespective of the type of measurement (outdoor or
10   indoor), the system 1 comprises a plurality of arrays of
deformable sensors (all indicated with 10 in figures 1, 2
and 3). In figure 1, in particular, ten arrays of sensors
10 are represented, whereas in figures 2 and 3 just two
arrays of sensors are represented. The arrays of sensors
15   10 are associated with a quadrangular support plate 3
(visible in figures 2 and 3) adapted to be housed in a
suitable seat 4 formed on the road surface (in case of
outdoor measurements, see figure 1) or on a rolling
runway 5 of a drum 6 simulating the road surface (in case
20   of indoor measurements, see figure 2). In this last case
the plate 3 is suitably calendared within the seat 4
formed on the drum 6.

The arrays of sensors are all arranged parallel along a
direction y transversal, perpendicular in the illustrated
25   example, to the motion direction x of the tyre 2 and
extend along the direction y for a length at least equal
to the dimension of the tyre 2 along said direction y. As
better illustrated in figure 3, the arrangement of the
various arrays of sensors 10 on the plate 3 is staggered
30   along the direction y.

The sensors 10 are, in particular, deformation sensors,
i.e. elements having the capability to concentrate
electrical charges when subjected to deformation and then
generate an electrical signal proportional to such a
35   deformation. In particular, each of the sensors 10

comprises a piezoelectric element which is subjected to deformation as the tyre 2 passes over the sensor and generates an electrical signal proportional to the speed of deformation, i.e. to the speed of impact with the tyre 2, or in other words to the variation of pressure undergone by the sensor 10.

In the example illustrated in figures 1 to 5, and with particular reference to figures 4 and 5, the sensor 10 comprises a main body 11 in which a longitudinal through-hole 12, a longitudinal threaded through-hole 13 and a transversal through-hole 14 are formed. The through-hole 12 is formed at an upper portion of the main body 11 and has two portions of hole 12a and 12b, upper and lower respectively, with a different diameter, the portion of hole 12b having a diameter greater than that of the portion of hole 12a. The threaded hole 13 is formed coaxially to the hole 12 at a lower portion of the main body 11. The transversal hole 14 is placed between the through-hole 12 and the threaded hole 13.

A plunger 120 made of steel is slidably housed in the through-hole 12. In particular, the plunger 120 comprises a first plunger portion 120a slidably housed in the portion of hole 12a, and a second plunger portion 120b with a greater diameter slidably housed in the portion of hole 12b.

A piezoelectric cable 140, which constitutes the deformable element of the sensor 10, is housed in the transversal hole 14. Such a cable is held always in contact with the plunger 120 by means of a preload screw 130 housed in the threaded hole 13.

In the main body 11, between the portion of hole 12a and the portion of hole 12b, an annular crown 110 is defined which is suitable for acting as an abutment surface for the plunger portion 120b. The annular crown 110 thus constitutes a mechanical stop for the plunger 120 which

is thus prevented from escaping from the main body 11
through the portion of hole 12a.

The plunger 120 is sized so that, when the plunger
portion 120b abuts upon the annular crown 110 of the body
5   11, an end portion 121 of the plunger 120 slightly
protrudes from the upper face 11a of the main body 11,
whereas the lower plunger portion 120b contacts the
piezoelectric cable 140. The tyre 2, when passing on the
sensor 10, impacts with the upper portion 121 of the
10 plunger 120. The plunger is thus pushed to slide
downwards, thus pressing upon the piezoelectric cable 140
which is thus deformed and which generates an electrical
signal proportional to the speed of deformation, i.e. to
the variation of pressure undergone.

15 The assembly of the sensor 10 takes place by firstly
inserting the plunger 120 in the through-hole 12 through
the threaded hole 13, then inserting the piezoelectric
cable 140 in the transversal hole 14 and finally screwing
the preload screw 130 into the hole 13 till the plunger
20 120 abuts the annular crown 110 of the main body 11 and
gives the piezoelectric cable 140 the correct static
preload.

The main body 11 has an outer threading 111 suitable for
allowing the screwing of the sensor 10 into the plate 3.
25 In substance, the body 11 consists of a hollow screw.

In an alternative embodiment (not illustrated) of the
sensor 10, the piezoelectric cable 140 is arranged in a
groove formed on the head of a screw which is in turn
associated with the plate 3, or directly with the road
30 surface or with the drum simulating the road surface, so
as to be pressed directly by the tyre 2. Such a
structural configuration of the sensor 10 is, however,
less preferred with respect to the one described above
which provides for the use of the plunger 120. This last
35 configuration, indeed, ensures less distorted signals,

greater amplifications and less wear of the piezoelectric cable 140.

The detection of the size and/or shape of the footprint area of a tyre takes place in the following way.

5   In outdoor detection systems (see figure 1), the vehicle which carries the tyre 2 is made to pass over the sensors 10 which are previously housed in the road surface. Upon contact with the tyre 2, each sensor 10 generates an electrical signal proportional to the speed of
10   deformation.

The electrical signals obtained by the various sensors 10 are transmitted, through screened cables 20 suitably associated with the sensors 10 (and preferably through an amplification system 21) to a digital acquisition card of
15   a data processing station 22, which takes care of extracting the desired information from the signals. The speed of the tyre 2 is detected through photocells 23 provided upstream of the sensors 10 along the motion direction x of the tyre 2. The signal generated by the
20   photocells 23 is sent to the data processing station 22.

In indoor detection systems (see figure 2), the sensors 10 are housed on the rolling runway 5 of a drum 6 simulating the road surface. The tyre 2 is fitted onto the hub of a dynamometric rod 30 and is brought into
25   contact with the drum 6 while controlling the vertical load, the slip and the camber. The rolling of the tyre 2 (at the predetermined speed) takes the sensors 10 into contact with the tyre 2, thus generating the electrical signals. Also in this case, the electrical signals
30   obtained by the various sensors 10 are transmitted, through screened cables 20 suitably associated with the sensors 10 and connected through a rotary collector 20a, to a digital acquisition card of a data processing station 22, which takes care of extracting the desired
35   information from the signals. Preferably, also in this

case the signals are first amplified by an amplification
system 21.

As illustrated in figure 6, the electrical signal
generated by each sensor 10 typically has a trend which
5   from zero rapidly reaches a maximum amplitude (MAX) at a
zone of first contact between sensor and tyre and, after
a transition phase, a minimum amplitude (MIN) at a zone
of end of contact between sensor and tyre. The spatial
distance between these two characteristic points is
10 proportional to the length of the footprint area measured
at the position in which the sensor 10 is located. Such a
length can easily be calculated knowing the motion speed
of the tyre 2.

The overall shape and size of the footprint area are
15 obtained by combining the analogue information obtained
from the other sensors 10 arranged at different positions
on the footprint. Since the signal emitted by each signal
10 is proportional to the speed of deformation thereof,
and therefore to the variation of pressure on the sensor,
20 an index of distribution of pressure on the footprint
area of the tyre 2 is obtained by integrating such a
signal in time. With the integrals coming from the other
sensors the distribution of pressure on the whole of the
footprint area of the tyre 2 is then determined.

25   EXAMPLE

The Applicant has carried out a series of tests to detect
the size and shape of the footprint area of a tyre, the
distribution of pressure on such a footprint area and the
evolution of such properties as the inflation pressure of
30 the tyre, its motion speed and the vertical load vary.
Analogous tests have been carried out to measure
characteristic properties of a tyre in conditions of
right and left slip.

An indoor detection system of the type described in

figure 2 was used. Seven sensors, of the type illustrated
in figures 3 to 5, were arranged in an array on a rolling
runway of a drum simulating the road surface. The tyre to
be monitored was mounted onto a dynamometric rod and was
5   brought into contact with the drum. The tyre was made to
rotate initially at a speed of 30 Km/h. The vertical load
on the contact area between tyre and drum simulating the
road surface was initially 3.000 N.

The signal obtained by each sensor had a trend as a
10   function of time as illustrated in figure 6. Along the X-
axis the time in seconds is shown and along the Y-axis
the electrical signal in Volts is shown. The length of
the footprint area at each sensor was determined by
measuring the spatial distance between the point of
15   maximum amplitude and the point of minimum amplitude of
the signal and by multiplying such a distance by the
speed of rotation of the tyre. The overall shape and size
of the footprint area were obtained by combining the
analogue information of the other sensors of the array.

20   By integrating the signal emitted by each sensor an index
of distribution of pressure on the footprint was then
obtained. By combining the analogue information obtained
by the other sensors a three-dimensional pressure map was
determined.

25   The aforementioned operations were repeated for different
speed levels of the tyre and for different vertical loads
acting upon the tyre. The following graphs and/or maps
were obtained.

The graph of figure 7 represents the signal (V) emitted
30   by a sensor as a function of the number of sampling
points (given the frequency of sampling a matrix of times
is reconstructed and, knowing the motion speed of the
tyre, the space vector is reconstructed) for six linearly
increasing loads (Q) expressed in Newton. The graph of
35   figure 8 shows the signals of figure 7 integrated

numerically based upon the vector number of sampling points (Volts per unit).

The graph of figure 9 represents the length (a) in metres of the measured footprint at a sensor for six increasing
5   loads (Q) expressed in Newton. It can be seen how the length of the footprint increases as the vertical load increases.

The graph of figure 10 shows the map of the footprint area considering all of the sensors of the array and for
10   eight increasing vertical loads. Along the X-axis the position (b) of the various sensors (in metres) along the array (and therefore the width of the footprint area) is shown and along the Y-axis the length (a) of the footprint area (in metres) at each sensor is shown,
15   whereas the variation parameter is the vertical load expressed in Newton (N). Such a graph substantially shows the shape and size (length (a) and width (b)) of the footprint area of the tyre for eight different loads. It can be seen how the footprint area increases as the
20   vertical load increases.

The graph of figure 11 compares the map of figure 10 with the one-obtained in static conditions (V=0) with the same vertical loads.

The graph of figure 12 shows a three-dimensional map of
25   the distribution of pressure on the footprint area. The horizontal axes show the position (b) of the sensors in the array (and thus the width of the footprint area) and the length (a) of the footprint area at each sensor. The vertical axis shows the signals of figure 7 integrated
30   numerically based upon the vector number of sampling points (Volts per unit). The effect of a small camber angle should be noted: on the right there is a significant distribution of pressure.

The graphs of figures 13a and 13b show the evolution of

the size (length (a) and width (b)) of the footprint for
a right and left slip test, respectively, for different
slip angles expressed in radians. The maps of figures 14a
and 14b, on the other hand, show the map of distribution
5   of pressure on the footprint area for a 2 degree right
and left slip test, respectively. The specular behaviour
of the footprint is clear.

Figures 15a, 15b, 15c show the maps of distribution of
pressure on the footprint area for three increasing
10   levels of inflation pressure expressed in Pascal (Pa) and
figure 15d shows the relative shapes of the footprint
area. It can be seen how the footprint area reduces as
the inflation pressure increases, with a constant
vertical load.

15   Figures 16a, 16b, 16c show the maps of distribution of
pressure on the footprint area for three increasing
levels of vertical load expressed in Newton (N) and
figure 16d shows the relative shapes of the footprint
area. It can be seen how the footprint area increases as
20   the vertical load increases.

Figures 17a, 17b, 17c show the maps of distribution of
pressure on the footprint area for three increasing
levels of motion speed (V1, V2, V3, equal to 50, 100, 150
Km/h, respectively) and figure 17d shows the relative
25   shapes of the footprint area.

The previous description was made with particular
reference to a preferred embodiment of the system and/or
method of the present invention and to some variants
thereof. The man skilled will however will understand
30   that many other modifications or further alternatives can
be taken into consideration without departing from the
scope of protection of the present invention as claimed
hereafter. For example, instead of piezoelectric cables
it is possible to use piezoelectric film or quartz
35   elements or, in general, any material which, when

deformed, produces a concentration of electrical charge
and, therefore, an electrical signal. Moreover, the
distance between the maximum and minimum amplitude of the
electrical signal generated by the sensors was taken into
5   consideration to calculate the length of the footprint
area. Such a length can however be calculated by taking
into consideration the zeros of the integrals in time of
such a signal, or two other reference points of the
signal. In any case, it is possible to obtain a quantity
10   correlated with the length of the footprint at a specific
sensor, provided the criterion of choice of the
characteristic points is always the same for all of the
sensors of the array of sensors. Moreover, the
transmission of the signals from the sensors 10 to the
15   data processing station 22 can be carried out through
radio frequency transmitters.